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AN INDEX OF THE PHYSICAL VOLUME OF PRODUCTION

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II. MINING, 1879–1919

SCOPE AND METHOD

PHYSICAL production, economically considered, assumes three major forms: agriculture, mining, manufacture. The present study of the physical volume of production recognizes this basic differentiation of industry. In Part I, appearing in the September issue of the REVIEW, an analysis was made of the course of agricultural production in the United States from 1879 to 1920. In the present part, a parallel study is undertaken of the physical volume of production in mining from 1879 to 1919. A subsequent installment will deal with the volume of production in manufacture.

The methods followed in the analysis of mineral production are those devised and explained in the study of the physical volume of production in agriculture. It will be recalled that two distinct indices of agricultural production were developed: an "unadjusted" and an "adjusted" index. Similar unadjusted and adjusted indices of the physical volume of production in mining are calculated in the present part of the study. A recapitulation of the methods of computing these indices seems desirable.

The unadjusted index is of the fixed-base type. It is arrived at by a few comparatively simple steps. The original items of each series are first reduced to percentages of a base for the series, this base being the arithmetic average of the items of the five-year pre-war period, 1909–13. The several commodities are next assigned weights equal to their respective average annual aggregate values during the same base period, 1909–13. Finally a weighted geometric mean of the relatives of each year is computed. These weighted geometric means for the years of the period of study constitute the unadjusted index.

The adjusted index is calculated by entirely different methods. The normal or secular trend of each series is first determined. The original items of each series are then expressed as percentages of the corresponding ordinates of the series' line of secular trend. Finally a weighted arithmetic mean of the relatives of each year is calculated, the same weights being used as in the computation of the unadjusted index. The adjusted index consists of these weighted arithmetic means.

These methods are made to yield in Part II not only the two indices of mining but, in addition, corresponding indices of the total production of agricultural and mineral raw materials. The unadjusted raw-material index combines the separate unadjusted agricultural and mineral indices as a weighted geometric mean; the adjusted raw-material index combines the separate adjusted indices as a weighted arithmetic mean. In both raw-material indices, the weights assigned to agriculture and mining are proportionate to the aggregate values of agricultural and mineral production in the United States in the last pre-war census year, 1909. The raw-material indices are thus only a logical extension of the methods adopted in the construction of the indices for agriculture and mining.

MATERIAL UTILIZED

The individual series used in the construction of the mining indices consist of the records of annual production of six metallic and four non-metallic minerals. The ten commodities included are gold, silver, pig iron, copper, lead, zinc, anthracite coal, bituminous coal, petroleum, and coke. In this group of ten are included all the more important minerals produced in the United States except limestone, sand, clay, rock, and natural gas.[1] For these five, no adequate data on physical production are available. For the ten minerals included in the study, the data, save for a few unimportant items, are satisfactory for the entire period from 1879 to 1919.

The ten minerals upon which the indices are based vary widely in the uses to which they are put, the localities in which they are produced, and the character of the data in which the volume of their production is recorded. A brief examination of each series with reference to these points will be profitable.

Gold. This series gives in fine troy ounces the production from domestic ores. During the past generation gold has been firmly established as the world's standard monetary metal. For centuries before, silver had shared this honor with gold. Despite the position which gold occupies in the realm of money, industrial consumption takes an increasing proportion of the new production of the metal.[2] The principal industrial consumers of gold are the manufacturers of jewelry, watches, and dental supplies. The producers of leaf and ornaments, and of photographic and chemical materials also use substantial amounts. Before the war about one-third of new production in the United States appeared to be going into industry and the arts, two-thirds into money. Gold mining in the United States centers in the West. The most prolific regions are California, Alaska, Colorado, South Dakota, and Nevada.

Silver. This series shows in fine troy ounces the total production from domestic ores and gravels. The white precious metal, like the yellow, flows extensively into both industrial and monetary uses. In manufacture, silver is employed chiefly in the production of electrical instruments, ornaments and tableware. In coinage, silver is struck in most countries largely in subsidiary denominations; but in China and India silver is preferred even for the major pieces, and practically the entire monetary stock is composed of the white metal. The habit of hoarding which prevails in the Far East results in the withdrawal of large amounts of coin from circulation. As a consequence great quantities of silver virtually disappear in countries like India and China. This "drain of silver to the East" is one of the fundamental phenomena of modern monetary experience. The leading producing states in silver mining in this country are Montana, Utah, Nevada, and Idaho. Colorado and Arizona also mine large quantities.

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[1] Cement should be added to the omissions if the production of cement is to be considered an extractive rather than a manufacturing industry. The 1910 Census classification of Portland cement production as manufacture has seemed a sufficient warrant for eliminating cement in the construction of the mining indices.

[2] See "The World's Industrial Consumption of Gold" by Eunice S. Coyle in REVIEW OF ECONOMIC STATISTICS, June, 1920.

Pig Iron. The series used covers all kinds of pig iron, including such ferro alloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus. Total production comprises the entire crude product of blast and electric furnaces in which iron ore is smelted. Pig iron is largely converted into steel. It is used in an infinite variety of forms in industrial structures and machinery. Foreign trade in pig iron is relatively small but an increasing amount of business is done in the more highly fabricated iron and steel products. The leading states in the production of pig iron in the United States are Pennsylvania, Alabama, Ohio, and Indiana. The bulk of the ore is drawn from the Lake Superior district. Forty per cent of the world's iron ore is produced in this country.

Copper. This series is of smelter output. Data on mine production or refinery output might be used, but smelter output is generally thought to be a more accurate index of the country's production. Moreover, records of smelter output are available for a much longer period than data in other forms. Copper is of great industrial importance both by itself and in such alloys as brass, bronze and gun metal. The electrical, shipbuilding and automobile industries, and the railroads, are large consumers of the metal. Governments take substantial quantities for coinage. Production in the United States supplies many other countries. In the five years preceding the war, domestic consumption equaled only about two-thirds of domestic production. The production of copper in the United States lies chiefly in Arizona, Montana, Michigan, and Utah. Over one-half of the world's output is produced in this country.

Lead. This series is of production of primary lead from domestic ores and base bullion, antimonial lead excluded. Lead is used extensively in industry for piping, ammunition, and pigments. It also enters a number of important alloys. Lead is mined in the United States chiefly in Missouri, Idaho, Colorado, and Utah. About 30 per cent of the world's production comes from the United States.

Zinc. This series is of smelter output of primary metal from domestic ores. Data on mine production are available from 1908. Zinc is commercially called spelter. The chief use of the metal pure is for galvanizing iron and steel to prevent rust. Sheet zinc is used in considerable quantities. The metal is one of the important constituents of brass. Foreign trade in zinc is not large. The chief zinc-mining states in this country are Missouri, New Jersey, Montana, and Oklahoma. The United States contributes at least 30 per cent of the world's production.

Anthracite coal. The production of Pennsylvania anthracite in net tons is the series taken. This makes a satisfactory series for the industry as a whole since the mining of anthracite is largely confined to Pennsylvania. Anthracite is the hard black lustrous coal containing 85–95 per cent carbon, as contrasted with 70–85 per cent carbon in bituminous coal. Anthracite is essentially a fuel for household consumption.

Bituminous coal. The series used consists of total annual production in net tons. Bituminous coal is the fuel of industry. It is used in generating steam for power and heating, and in making coke, gas, tar, and other products of commercial importance. The chief producing states in the mining of bituminous coal in this country are Pennsylvania, West Virginia, Illinois, and Ohio.

Petroleum. This series consists of the marketed production in barrels of 42 gallons. In earlier years, the series was referred to as production in the United States. The data appear, however, always to have been of the amount of petroleum marketed. Crude petroleum is a liquid mixture of numerous hydrocarbons, varying widely in composition and appearance. It is used extensively in the crude state as a fuel and lubricant. The refined products number several hundred, and are put to a great variety of uses in industry and the arts. Seven large fields furnish the marketed production of the United States. The principal producing states at present are Oklahoma, California, Kansas, and Texas.

Coke. The total production of by-product and bee-hive coke in short tons is the series taken. From 1879 to 1893 only bee-hive coke was produced. Since 1893 both methods have been employed and the series is of total production from the two combined. Ordinary gas coke obtained as a by-product in the manufacture of illuminating gas is not included. The series is of oven coke; that is, of coke obtained by the distillation or partial combustion of bituminous coal in retorts or ovens. Coke is coal from which the volatile constituents have been driven by heat so that the fixed carbon and gas are fused together. It is commonly artificial but is known also to be found native. It is difficult to ignite but burns with great heat and without smoke. This quality makes it valuable for metallurgical operations. Formerly coke was used chiefly as blast furnace fuel. Now many important products are obtained from by-product coke ovens: *e. g.*, raw material for the manufacture of explosives, dyes, and ammonia; products used in building roads and roofs; oils for ore flotation; artificial gas for illumination and heat. Pennsylvania, Alabama, Ohio, and Indiana are the chief coke-producing regions in the United States.

SOURCES OF INFORMATION

(a) *General*

The most important single authority regarding mineral production in the United States is the United States Geological Survey. This government office receives reports from practically all domestic mineral producers, smelters, refiners, and mill men. Many reports are also received from manufacturers of mineral products and from owners of mines, quarries, and wells temporarily inactive. Investigation is carried on by the Survey by correspondence, by conferences in Washington and elsewhere, and by field work of specialists in the employ of the government. The Survey data on mineral production are published chiefly in an annual report entitled *Mineral Resources of the United States.* This report is in two parts, one dealing with metals, the other with non-metals. The report is prepared by the Division of Mineral Resources of the Geological Survey. This Division works in coöperation with the Division of Geology, and most of the sections of the reports on mineral resources are compiled by geologists who work in both divisions of the Survey and specialize on individual mineral products.

The only other agencies contributing current data used in the present study are the United States Bureau of the Mint and the American Iron and Steel Institute. The former, which is a federal bureau, coöperates in the compilation of the gold- and silver-production series; and the latter, a private agency, is generally recognized as the highest authority on the subject of iron and steel production in this country. The work of these two agencies will be referred to again in connection with the individual series for which they are responsible.

(b) *Individual Series*

Gold. This series was first compiled by the Bureau of the Mint alone from the records of its several offices. Originally no gold was included which did not find its way to the government for assay. Beginning with 1885 the Mint included in the series the relatively small amounts sold by private refineries directly to manufacturers and dealers. Since 1905 the Bureau of the Mint and the Geological Survey have coöperated in the compilation of the gold-production series. The contribution of the Survey, however, is largely in the distribution of the total product among the several producing states. In the present series total production comprises the amounts received at the Mint offices and private refineries plus the metal contained in small amounts of matte and ore exported.

Silver. For the years before 1905 this series consists of estimates made by the Bureau of the Mint. Since then the Bureau of the Mint and the Geological Survey have conferred annually and agreed upon a final figure for total production. Throughout the series, estimates of production are based upon deposits at mint offices and private refineries and on metal contained in exported ore and matte.

Pig Iron. The annual statistical report of the American Iron and Steel Institute furnishes the series of pig-iron production. Even the United States Geological Survey accepts the Institute's figures as official. The Institute appears to collect its statistics from the iron and steel manufacturers, but no specific description of the method of compilation seems to have been published. The pig-iron series apparently includes some output from foreign ores but the amount from this source can hardly be appreciable.

Copper. Data on copper production appear in the report of the Geological Survey on *Mineral Resources.* The data for the years from 1882 to 1919 are based on returns to the Geological Survey by the copper producing companies. For the years prior to 1882 the figures rest upon information drawn by the Survey from miscellaneous sources.

Lead. This series is taken from the Geological Survey report on *Mineral Resources.* There being no official records before 1882, the Survey compiled a series for earlier years from the best available sources. The Survey borrows the figure for 1889 from the Bureau of the Census; all other figures from 1882 to date are the result of the Survey's own investigations.

The Survey's method of compiling data on lead production has undergone certain changes the effects of which are not altogether clear. At first, the data were based upon refiners' records which were said to be more accurate than returns from smelters. In 1886, when foreign ores began to come in, production was computed by subtracting from the total refined output the lead estimated to be contained in ores imported. This method was continued until 1894 when the smelters began reporting the quantities of lead extracted from ores obtained by them from different states and territories. These returns enabled the Survey to secure directly a total of domestic production. The current figures are obtained in this way. In 1908, the data for 1894–99 and 1901–05 were revised without explanation. In 1914, antimonial lead was excluded for the entire series. Previously, the exclusion had not been made for the years before 1906.

Zinc. This series, appearing annually in the Geological Survey report on *Mineral Resources*, is based upon confidential reports of spelter producing concerns. Where information is refused, estimates are made by the Survey. Except during the first year or two of collection, smelters have almost uniformly reported their output.

Coal, Anthracite and Bituminous. Production of anthracite and bituminous coal is reported annually in Part II of the Survey report on *Mineral Resources.* The series is based upon regular reports to the Geological Survey from coal operators and producers and upon special reports from state geologists.

Petroleum. This series appears in Part II of the Survey report on *Mineral Resources.* The data are drawn from returns made by pipe lines, railroads, and oil producers. Since 1906 the regular collection of data has been supplemented by direct reports from all oil producing companies.

Coke. Production of coke is reported in Part II of the Survey annual report on *Mineral Resources.* The series is based upon special returns made by each individual coke producer for each separate establishment.

These ten mineral series, obtained from the sources indicated, constitute the material for constructing the unadjusted and adjusted indices of the volume of mineral production in the United States. The individual series all appear in Table XI. They are plotted with their lines of normal trend in the individual diagrams of Charts XI and XII.

TABLE XI. — ANNUAL PHYSICAL PRODUCTION OF TEN IMPORTANT MINERALS, 1879–1919

Year	Gold *mill. fine oz.**	Silver *mill. fine oz.**	Pig iron *mill. long tons*	Zinc *thous. sh. tons*	Lead *thous. sh. tons*	Copper *million lbs.*	Bituminous coal *million sh. tons*	Anthracite coal *million sh. tons*	Petroleum *million bbls.* †	Coke *million sh. tons*
1879	1.882	31.57	2.74	....	91	52	37.9	30.21	19.9	....
1880	1.742	30.32	3.84	....	96	60	42.8	28.65	26.3	3.34
1881	1.679	33.26	4.14	....	114	72	54.0	31.92	27.7	4.11
1882	1.572	36.20	4.62	33.8	130	91	68.4	35.12	30.4	4.79
1883	1.451	35.73	4.60	36.9	140	116	77.2	38.46	23.4	5.46
1884	1.490	37.74	4.10	38.5	136	145	83.0	37.16	24.2	4.87
1885	1.538	39.91	4.04	40.7	126	166	72.8	38.34	21.9	5.11
1886	1.687	39.69	5.68	42.6	127	158	74.6	39.03	28.1	6.84
1887	1.603	41.72	6.42	50.3	142	182	88.6	42.09	28.3	7.61
1888	1.604	45.79	6.49	55.9	147	226	102.0	46.62	27.6	8.54
1889	1.595	50.09	7.60	58.9	152	227	95.7	45.55	35.2	10.26
1890	1.589	54.52	9.20	63.7	140	260	111.3	46.47	45.8	11.51
1891	1.605	58.33	8.28	80.9	175	284	117.9	50.67	54.3	10.35
1892	1.597	63.50	9.16	87.3	168	345	126.9	52.47	50.5	12.01
1893	1.739	60.00	7.12	78.8	159	329	128.4	53.97	48.4	9.48
1894	1.911	49.50	6.66	75.3	154	354	118.8	51.92	49.3	9.20
1895	2.255	55.73	9.45	89.7	160	381	135.1	58.00	52.9	13.33
1896	2.568	58.84	8.62	81.5	180	460	137.6	54.35	61.0	11.79
1897	2.775	53.86	9.65	100.0	198	494	147.6	52.61	60.5	13.29
1898	3.118	54.44	11.77	115.4	202	526	166.6	53.38	55.4	16.05
1899	3.437	54.76	13.62	129.1	202	569	193.3	60.42	57.1	19.67
1900	3.830	57.65	13.79	123.9	261	606	212.3	57.37	63.6	20.53
1901	3.806	55.21	15.88	140.8	259	602	225.8	67.47	69.4	21.80
1902	3.870	55.50	17.82	156.9	267	660	260.2	41.37	88.8	25.40
1903	3.560	54.30	18.01	159.2	281	698	282.8	74.61	100.5	25.27
1904	3.892	57.68	16.50	186.7	298	812	278.7	73.16	117.1	23.66
1905	4.266	56.10	22.99	203.8	308	889	315.1	77.66	134.7	32.23
1906	4.565	56.52	25.31	199.7	336	918	342.9	71.28	126.5	26.40
1907	4.375	56.52	25.78	223.7	352	869	394.8	85.60	166.1	40.78
1908	4.574	52.44	15.94	190.7	312	943	332.6	83.27	178.5	26.03
1909	4.822	54.72	25.80	230.2	353	1093	379.7	81.07	183.2	39.32
1910	4.657	57.14	27.30	252.5	375	1080	417.1	84.49	209.6	41.71
1911	4.687	60.40	23.65	271.6	392	1097	405.9	90.46	220.4	35.55
1912	4.521	63.77	29.73	323.9	393	1243	450.1	84.36	222.9	43.98
1913	4.300	66.80	30.97	337.3	412	1224	478.4	91.52	248.4	46.30
1914	4.573	72.46	23.33	343.4	513	1150	422.7	90.82	265.8	34.56
1915	4.888	74.96	29.92	458.1	507	1388	442.6	89.00	281.1	41.58
1916	4.479	74.42	39.44	564.3	552	1928	502.5	87.58	300.8	54.53
1917	4.051	71.74	38.62	584.6	548	1886	551.8	99.61	335.3	55.61
1918	3.321	67.81	39.06	492.4	540	1909	579.4	98.83	355.9	56.48
1919	2.829	55.29	31.02	452.3	424	1311	458.1	86.20	377.7	44.82

* Troy weight. † Barrels of 42 gallons.

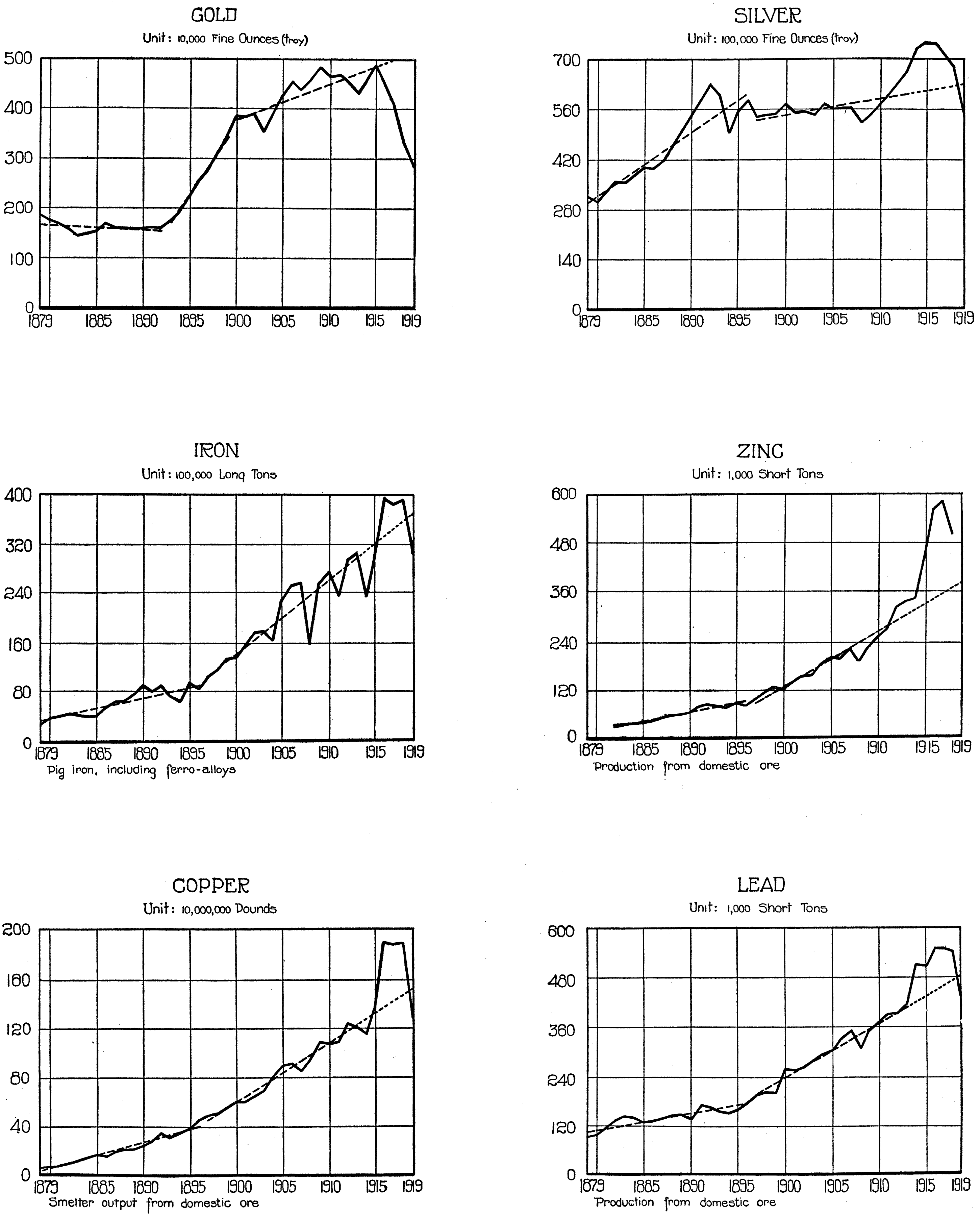

Chart XI. — Annual Physical Production of Gold, Silver, Iron, Zinc, Copper, and Lead, 1879–1919, Together with Lines of Secular Trend.

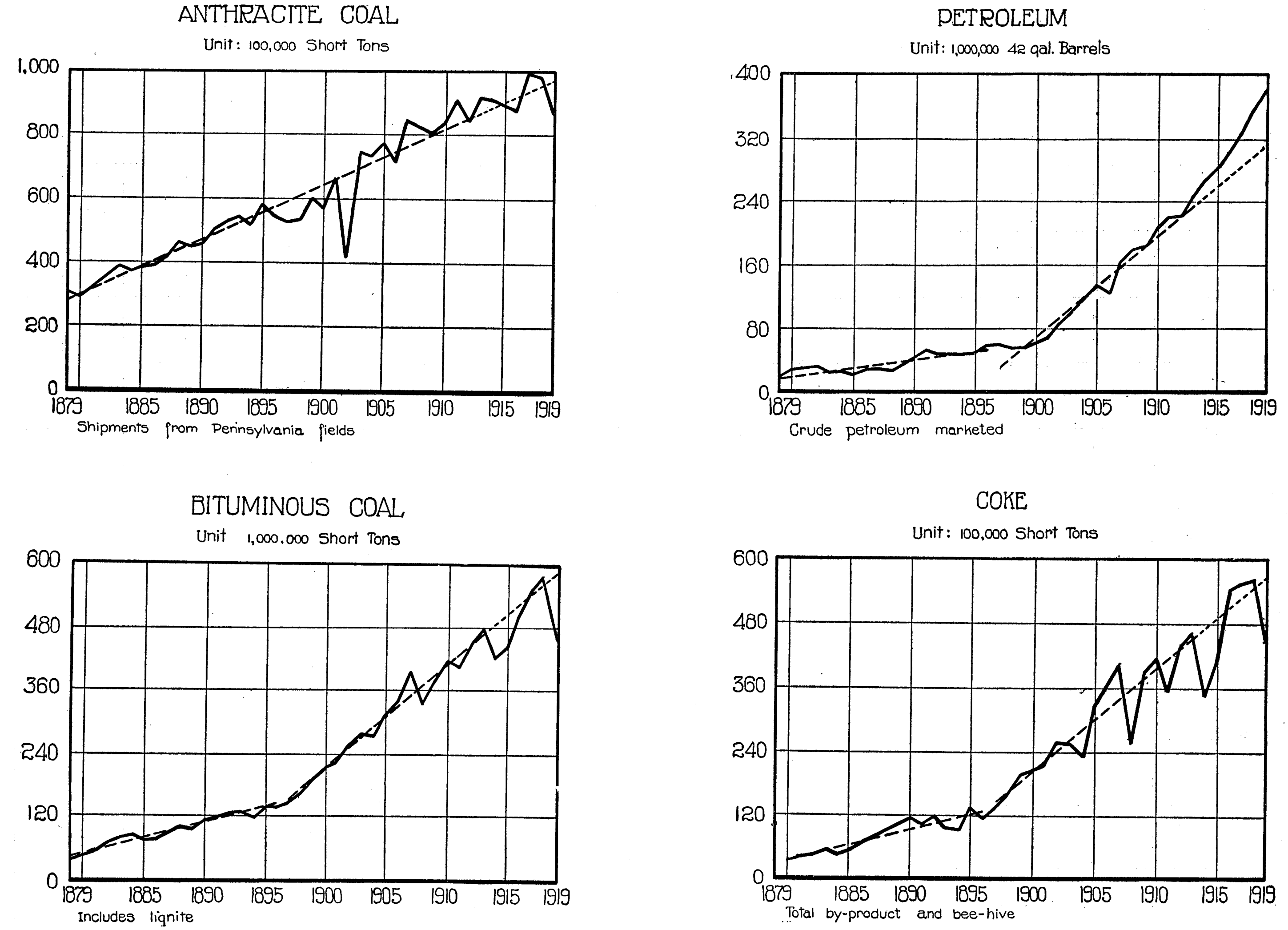

CHART XII. — ANNUAL PHYSICAL PRODUCTION OF ANTHRACITE COAL, BITUMINOUS COAL, COKE, AND PETROLEUM, 1879–1919, TOGETHER WITH LINES OF SECULAR TREND.

THE UNADJUSTED INDEX OF MINING

The methods of deriving the unadjusted index have already been reviewed. The initial steps are: first, to compute for each series the average of the items for the five years 1909–13; second, to express the original items of each series as percentages of the series' base-period average.

The averages for 1909–13 and the yearly relatives are given for all ten series in Table XII. The outstanding feature of the data is the extraordinary rise shown from 1879 to 1919 in several of the series. The output of copper in the United States increased twentyfold between 1879 and the years just before the war; the output of pig iron, exactly tenfold. In agriculture there are no comparable increases except in the cases of sugar and rice. Improved methods of extraction, discovery of previously unknown deposits, more intensive working of old mines, all have contributed to an increase of mineral production quite beyond the present possibilities of increase in agriculture.

Before the percentage relatives can be combined, the proportionate importance of the ten minerals have to be determined. The method adopted is that followed in the weighting of the twelve important agricultural products. It is assumed that the relative importance of commodities in the economic life of the country is proportionate to their typical annual aggregate values. Consequently, in weighting the ten important minerals, annual aggregate values of the yields for the years 1909–13 are first obtained and averaged, and then a set of proportions derived by making the lowest average annual aggregate value equal one and expressing the others as multiples of this lowest.[1] The annual aggregate values of the ten important minerals with the corresponding weights are given in Table XIII.[2]

The unadjusted index of production is finally obtained by computing for each year the weighted geometric mean of the percentage relatives. The reasons, explained in Part I, for adopting the geometric mean are: (1) the fact that the resulting index may be directly shifted from one base to another without introducing an error; and (2) the slight effect exercised upon the geometric mean by extreme, non-typical items.[3] These qualities of the geometric mean give it unmistakable

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[1] The method is perfectly consistent with that followed in the construction of the agricultural indices. The work of computation, however, is considerably simplified by the additional step of substituting one- and two-place proportionate figures for the average aggregate values in millions. Results by the two methods are practically identical.

[2] The average annual value of the ten minerals combined is approximately 85 per cent of the total value of mineral production in the United States during the same years. The twelve important crops included in the agricultural indices constitute almost exactly the same proportion of total agricultural production.

[3] For the formula of the weighted geometric mean, see the September number of the REVIEW, p. 255, footnote.

Table XII. — Relative Annual Physical Production of Ten Important Minerals, 1879–1919

(*Average for 1909–13 = 100*)

Year	Gold	Silver	Pig iron	Zinc	Lead	Copper	Bituminous coal	Anthracite coal	Petroleum	Coke
	*mill. fine oz.**	*mill. fine oz.**	*mill. long tons*	*thous. sh. tons*	*thous. sh. tons*	*million lbs.*	*million sh. tons*	*million sh. tons*	*million bbls.*†	*million sh. tons*
1909–13 (average)	4.597	60.57	27.49	283.1	385	1148	426.3	86.38	216.9	41.37
1879	40.9	52.1	10.0	....	23.6	4.5	8.9	35.0	9.2	....
1880	37.9	50.1	13.9	....	24.9	5.3	10.0	33.2	12.1	8.1
1881	36.5	54.9	15.1	....	29.6	6.2	12.7	36.9	12.8	9.9
1882	34.2	59.8	16.8	11.9	33.8	7.9	16.1	40.7	14.0	11.6
1883	31.7	59.2	16.7	13.0	36.4	10.1	18.1	44.5	10.8	13.2
1884	32.4	62.3	14.9	13.6	35.3	12.6	19.5	43.0	11.2	11.8
1885	33.4	65.9	14.7	14.4	32.7	14.4	17.1	44.4	10.1	12.3
1886	36.8	65.5	20.7	15.1	33.0	13.7	17.5	45.2	12.9	16.5
1887	34.9	68.9	23.3	17.8	36.9	15.8	20.8	48.6	13.0	18.4
1888	34.9	75.6	23.6	19.7	38.2	19.7	23.9	54.0	12.7	20.6
1889	34.7	82.7	27.7	20.8	39.5	19.8	22.4	52.7	16.2	24.8
1890	34.6	90.0	33.5	22.5	36.4	22.6	26.1	53.8	21.1	27.8
1891	34.9	96.3	30.1	28.6	45.5	24.8	27.6	58.7	25.0	25.0
1892	34.7	104.8	33.3	30.8	43.7	30.1	29.7	60.7	23.3	29.0
1893	37.8	99.1	25.9	27.8	41.3	28.7	30.1	62.5	22.3	22.9
1894	41.6	81.7	24.2	26.6	40.0	30.9	27.8	60.1	22.7	22.2
1895	49.1	92.0	34.4	31.7	41.6	33.2	31.6	67.1	24.4	32.2
1896	55.9	97.1	31.4	28.8	46.8	40.1	32.3	62.9	28.1	28.4
1897	60.4	88.9	35.1	35.3	51.4	43.0	34.6	60.9	27.9	32.1
1898	67.9	89.9	42.8	40.8	52.5	45.9	39.1	61.8	25.5	38.8
1899	74.8	90.4	49.5	45.6	52.5	49.5	45.4	69.9	26.3	47.6
1900	83.4	95.2	50.2	43.8	67.8	52.8	49.8	66.4	29.3	49.6
1901	82.8	91.2	57.8	49.7	67.3	52.5	52.9	78.1	32.0	52.6
1902	84.2	91.6	64.8	55.4	69.4	57.4	61.0	47.9	40.9	61.5
1903	77.5	89.6	65.5	56.2	73.0	60.8	66.3	86.4	46.3	61.0
1904	84.8	95.2	60.0	66.0	77.4	70.8	65.4	84.7	54.0	57.2
1905	92.8	92.6	83.6	72.0	80.0	77.4	73.9	89.9	62.1	78.0
1906	99.4	93.3	92.0	70.5	87.3	80.0	80.4	82.5	58.3	63.8
1907	95.2	93.3	93.8	79.0	91.4	75.7	92.6	99.1	76.6	98.5
1908	99.5	86.6	58.0	67.4	81.1	82.1	78.0	96.4	82.3	63.0
1909	105.0	90.4	93.8	81.5	91.6	95.2	89.1	93.9	84.4	95.0
1910	101.3	94.3	99.3	89.2	97.4	94.1	97.9	97.8	96.6	100.9
1911	101.9	99.7	86.0	96.0	101.8	95.6	95.2	104.7	101.6	85.8
1912	98.4	105.3	108.1	114.0	102.0	108.3	105.6	97.7	102.8	106.1
1913	93.6	110.3	112.6	119.1	107.0	106.7	112.2	105.9	114.5	111.9
1914	99.6	119.6	84.9	121.3	133.3	100.2	99.2	105.1	122.5	83.4
1915	106.4	123.7	108.3	161.8	131.7	120.9	103.8	103.0	129.6	100.3
1916	97.4	122.8	143.4	199.3	143.4	168.0	117.9	101.4	138.6	131.8
1917	88.2	118.4	140.5	206.5	142.3	164.3	129.4	115.3	154.5	134.4
1918	72.3	111.9	142.0	173.9	140.3	166.3	135.9	114.4	164.1	136.5
1919	61.6	91.3	112.8	159.8	110.1	114.2	107.5	99.8	174.1	108.2

* Troy weight. † Barrels of 42 gallons.

advantages in the construction of such fixed-base indices as the unadjusted index of physical volume.

The unadjusted index of mineral production is given for the period 1879–1919 in Table XIV and Chart XIII. The increase in the physical volume of output is impressive. As a whole, mining in the United States multiplied its product ninefold between 1879 and 1909–13. From 1879 to 1907 the increase of mineral production from year to year was surprisingly even and steady, mining during this period standing in marked contrast

TABLE XIII. — AGGREGATE VALUES OF TEN IMPORTANT MINERALS, 1909–13

(Unit: $1,000,000)

Mineral	Weights used *	Average of five years 1909–13	1909	1910	1911	1912	1913
Bituminous coal	**15**	482	405	469	451	518	565
Pig Iron †	**13**	412	419	412	336	433	471
Anthracite coal	**5**	171	149	160	175	178	195
Copper	**5**	162	142	137	137	205	190
Petroleum	**5**	158	128	128	134	164	237
Coke	**3**	103	90	100	84	112	129
Gold	**3**	95	100	96	97	93	89
Silver	**1**	34	28	31	33	39	40
Lead	**1**	34	30	33	35	35	36
Zinc	**1**	33	25	27	31	45	38

* These weights are the round numbers obtained by dividing the average values for 1909–13 by 33. † Including ferro-alloys.

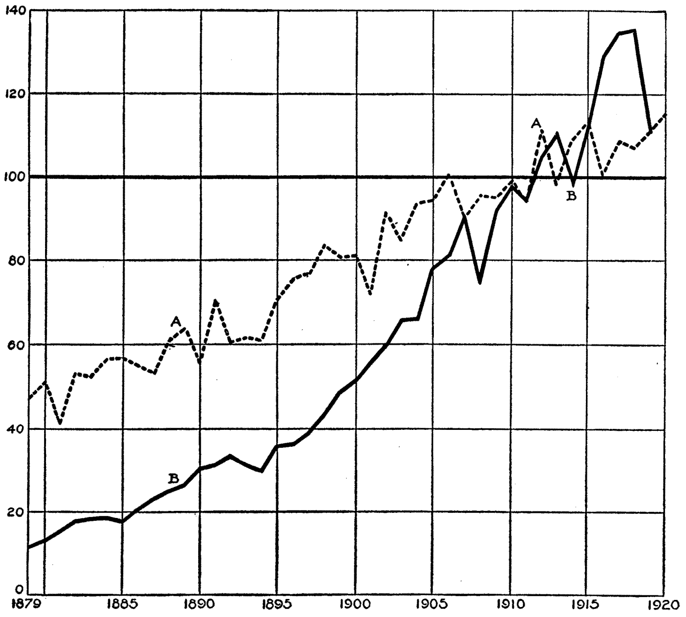

CHART XIII. — UNADJUSTED INDICES OF PHYSICAL PRODUCTION FOR (A) AGRICULTURE, 1879–1920, AND (B) MINING, 1879–1919.
(Average for 1909–13 = 100)

with agriculture. Since 1907, however, the output of mining has fluctuated widely, and the curves of the indices of mining and agriculture have a like "saw-tooth" appearance. Despite these irregularities it is clear enough that 1885, 1893 and 1894, 1904, 1908, 1911, 1914, and 1919 were years of relatively low production; and 1882, 1892, 1907, 1910, 1913, 1916–18, years of high. As was to be expected, the war greatly stimulated mining in this country and brought output to a height fully one-third above that of the years just before the outbreak of hostilities. The year following the signing of the armistice, however, witnessed a relapse, and the volume of mineral production in 1919 fell to the level of 1913.

Comparison of the course of mining with the growth of population and the increase of agriculture since 1879 discloses a number of significant facts. In Table XV, the unadjusted index of production for mining is given with the corresponding index of population; and in Chart XIV, the indices of mining, population, and agriculture are displayed together. The close parallelism of the increases in agriculture and population has already been discussed. Agricultural production kept ahead of population during the period 1879–1920, but without

TABLE XIV. — UNADJUSTED INDEX OF PHYSICAL PRODUCTION FOR MINING, 1879–1919

(Average for 1909–13 = 100)

Year	Index	Year	Index
1879	11.5	1900	51.3
1880	13.1	1901	55.6
1881	15.1	1902	59.5
1882	17.4	1903	65.5
1883	18.2	1904	66.1
1884	18.4	1905	78.4
1885	17.8	1906	80.9
1886	20.4	1907	90.2
1887	22.8	1908	74.8
1888	24.8	1909	91.9
1889	26.2	1910	97.8
1890	30.2	1911	94.3
1891	31.0	1912	105.1
1892	33.3	1913	110.2
1893	30.8	1914	98.3
1894	29.7	1915	110.4
1895	35.8	1916	129.5
1896	36.2	1917	134.5
1897	38.7	1918	135.6
1898	43.0	1919	110.8
1899	48.5		

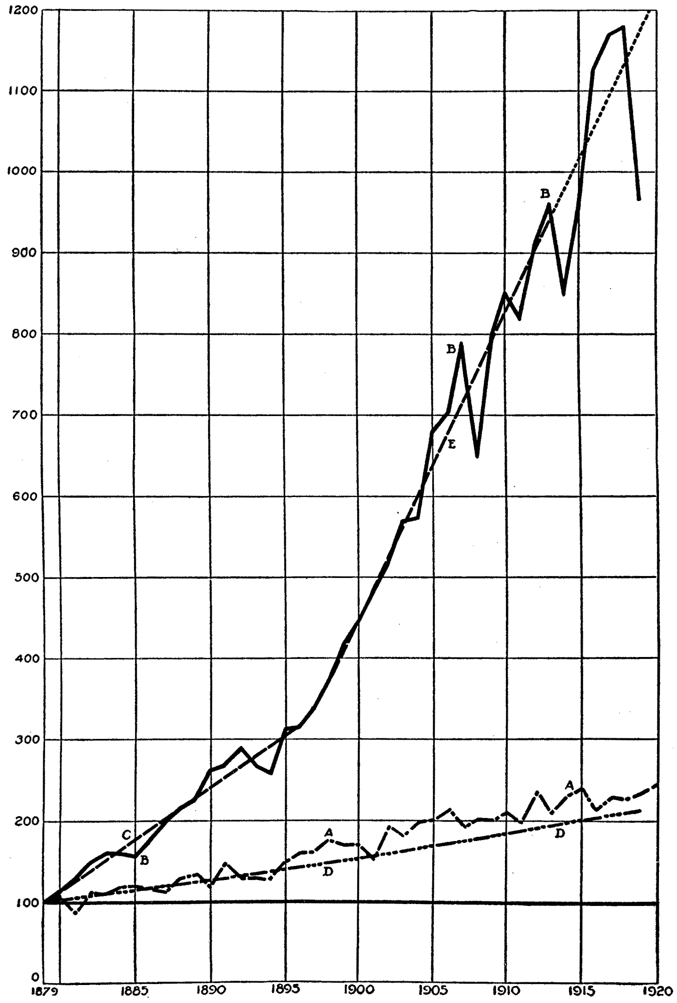

CHART XIV. — UNADJUSTED INDICES OF PHYSICAL PRODUCTION FOR (A) AGRICULTURE, 1879–1920, AND (B) MINING, 1879–1919, TOGETHER WITH (C AND E) LINES OF SECULAR TREND FOR MINING FOR THE PERIODS 1879–96 AND 1897–1913, RESPECTIVELY, AND (D) INDEX OF POPULATION.
(Items for 1879 = 100)

TABLE XV. — UNADJUSTED INDEX OF PHYSICAL PRODUCTION FOR MINING, COMPARED WITH INDEX OF POPULATION, 1879–1919

(Base: 1879)

Year	Population of Continental United States *million persons*	Index of population	Index of physical production for mining
1879	49.00	100.0	100.0
1880	50.16	102.5	113.9
1881	51.43	105.0	131.3
1882	52.71	107.6	151.3
1883	53.99	110.2	158.2
1884	55.27	112.8	160.0
1885	56.55	115.4	154.8
1886	57.83	118.1	177.4
1887	59.11	120.7	198.2
1888	60.39	123.2	215.6
1889	61.67	125.8	227.8
1890	62.95	128.5	262.6
1891	64.25	131.1	269.5
1892	65.56	133.4	289.5
1893	66.86	136.4	267.8
1894	68.17	139.2	258.2
1895	69.47	141.7	311.3
1896	70.78	144.4	314.7
1897	72.08	147.1	336.5
1898	73.39	149.6	373.8
1899	74.69	152.4	421.7
1900	75.99	155.1	446.0
1901	77.59	158.3	483.4
1902	79.19	161.5	517.2
1903	80.79	164.8	569.4
1904	82.39	168.2	574.7
1905	83.98	171.4	681.6
1906	85.58	174.6	703.4
1907	87.18	177.9	784.2
1908	88.78	181.2	650.3
1909	90.37	184.4	799.0
1910	91.97	187.6	850.3
1911	93.57	191.0	819.8
1912	95.17	194.2	913.9
1913	96.77	197.5	958.2
1914	98.36	200.6	854.6
1915	99.58	203.1	960.0
1916	100.80	205.5	1125.8
1917	102.02	208.0	1169.3
1918	103.24	210.5	1178.8
1919	104.46	213.0	963.4

much to spare. Mining output, upon the other hand, completely outdistanced population growth during the period 1879–1919. The more rapid gain of mining was noticeable even during the years of less rapid increase from 1879 to 1896. Since 1897, the development of mining has been phenomenal. Mineral resources have been exploited at a rate which makes agricultural growth look prosaic indeed. One of the fundamental contrasts between agriculture and mining thus is thrown into clear relief. Crops are an annual harvest from a soil the fertility of which scientific cultivation carefully preserves; mineral production is a continuing exhaustion of irreplaceable natural deposits. Mining typically lives upon its capital; agriculture, upon its income. The rate of production in mining is consequently open to an acceleration which in agriculture is altogether impossible.

THE ADJUSTED INDEX OF MINING

The adjusted index, unlike the unadjusted, is designed to make due allowance for increases or decreases of production which may be properly regarded as normal. Normality is defined for each mineral in terms of the persistent tendencies of its annual production. The conception is rendered obvious by reference to the individual diagrams of Charts XI and XII. In these diagrams, the lines of normal trend are shown for each series.

The lines of trend are mathematically determined. The methods by which they are derived have already been explained.[1] The equations of the lines, and the normal annual increases and 1913 yields which they imply, appear in Table XVI. With two exceptions, the lines of trend for the different series consist of two straight lines, one fitted to the period 1879–96, the other to the period 1897–1913, this second line being extended through the years 1914–19. In the case of anthracite coal, no break at 1896–97 is discernible, and a continuous straight line from 1879 to 1913 (extended to 1919) affords a thoroughly satisfactory fit. Only in the production of gold are the tendencies of an entirely different character. From 1879 to 1892, gold mining in the United States was hardly holding its own. Suddenly the industry took an extraordinary spurt which lasted from 1893 to 1900. From 1901 to 1915 the tendency of gold production was still strongly upward, but with marked irregularities from year to year. The lines of trend in gold mining are fitted to the three periods indicated. Straight lines suffice in all three cases. Aside from gold and anthracite coal, the trends exhibit a common characteristic: a moderate upward movement from 1879 to 1896, followed by a much more rapid advance from 1897 to 1913.

Following the determination of the lines of normal trend, the original items of each series are reduced to percentages of the corresponding ordinates of the lines of trend. If the trend of the bituminous coal series shows that an output of 271,350,000 short tons is indicated for 1903 and actual production turns out to be 282,750,000 tons, the relative for 1903 is 104.2 per cent. A relative of 100 means that actual production just equals the output required for the maintenance of the prevailing trend. Departures from 100, either above

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[1] See September REVIEW, p. 256, footnote, in which reference is made to the work of Professor Persons, as set forth in the REVIEW for January 1919, pp. 8–18.

TABLE XVI. — SECULAR TREND FOR TEN IMPORTANT MINERALS, 1879–1913

Minerals	Unit	LINE OF SECULAR TREND			Normal production 1913	Normal annual increase
		Equation	Period for which fitted	Origin		
Gold	Million fine oz. †	$y = -0.010x + 1.617$	1879–1892	1885–86 *		−0.010
		$y = 0.287x + 2.543$	1893–1899	1896		0.287
		$y = 0.070x + 4.324$	1900–1915	1907–08 *	4.710	0.070
Silver	Million fine oz. †	$y = 1.878x + 45.69$	1879–1896	1887–88 *		1.878
		$y = 0.471x + 56.93$	1897–1913	1905	60.70	0.471
Pig Iron	Million long tons	$y = 0.357x + 6.265$	1879–1896	1887–88 *		0.357
		$y = 1.182x + 20.26$	1897–1913	1905	29.72	1.182
Zinc	Thousand short tons	$y = 4.251x + 60.98$	1882–1896	1889		4.251
		$y = 13.37x + 196.8$	1897–1913	1905	303.8	13.37
Lead	Thousand short tons	$y = 4.120x + 140.9$	1879–1896	1887–88 *		4.120
		$y = 13.36x + 305.9$	1897–1913	1905	412.8	13.36
Copper	Million lbs.	$y = 22.51x + 217.0$	1879–1896	1887–88 *		22.51
		$y = 48.19x + 842.6$	1897–1913	1905	1228	48.19
Bituminous Coal	Million short tons	$y = 5.720x + 92.95$	1879–1896	1887–88 *		5.720
		$y = 19.73x + 310.8$	1897–1913	1905	468.7	19.73
Anthracite Coal .	Million short tons	$y = 1.759x + 57.46$	1879–1913	1896	87.36	1.759
Petroleum	Million bbls. ‡	$y = 2.242x + 36.39$	1879–1896	1887–88 *		2.242
		$y = 12.87x + 135.5$	1897–1913	1905	238.4	12.87
Coke	Million short tons	$y = 0.821x + 8.154$	1880–1896	1888		0.821
		$y = 1.903x + 29.88$	1897–1913	1905	45.11	1.903

* Midway between two years indicated. † Troy weight. ‡ Barrels of 42 gallons.

or below, suggest the influence of factors of a less persistent character — unusual efficiency or inefficiency of labor, exceptionally favorable or unfavorable weather conditions, abundant or inadequate transportation facilities, a passing phase of the business cycle, and the like. The percentage relatives of the ten mineral series, thus conceived, are given in full in Table XVII.

The final step in the construction of the adjusted index is the calculation of a weighted arithmetic mean of the percentage relatives of each year from 1879 to 1919. The ten minerals are weighted, as before, in the proportions of their respective average annual aggregate values during the pre-war period, 1909–13. The adjusted index for mining, thus obtained, is shown in Table XVIII. In Chart XV it is plotted in full line, with the corresponding index for agriculture in dotted.

Several conclusions are to be drawn from the table and chart of the adjusted index. In the first place, it is

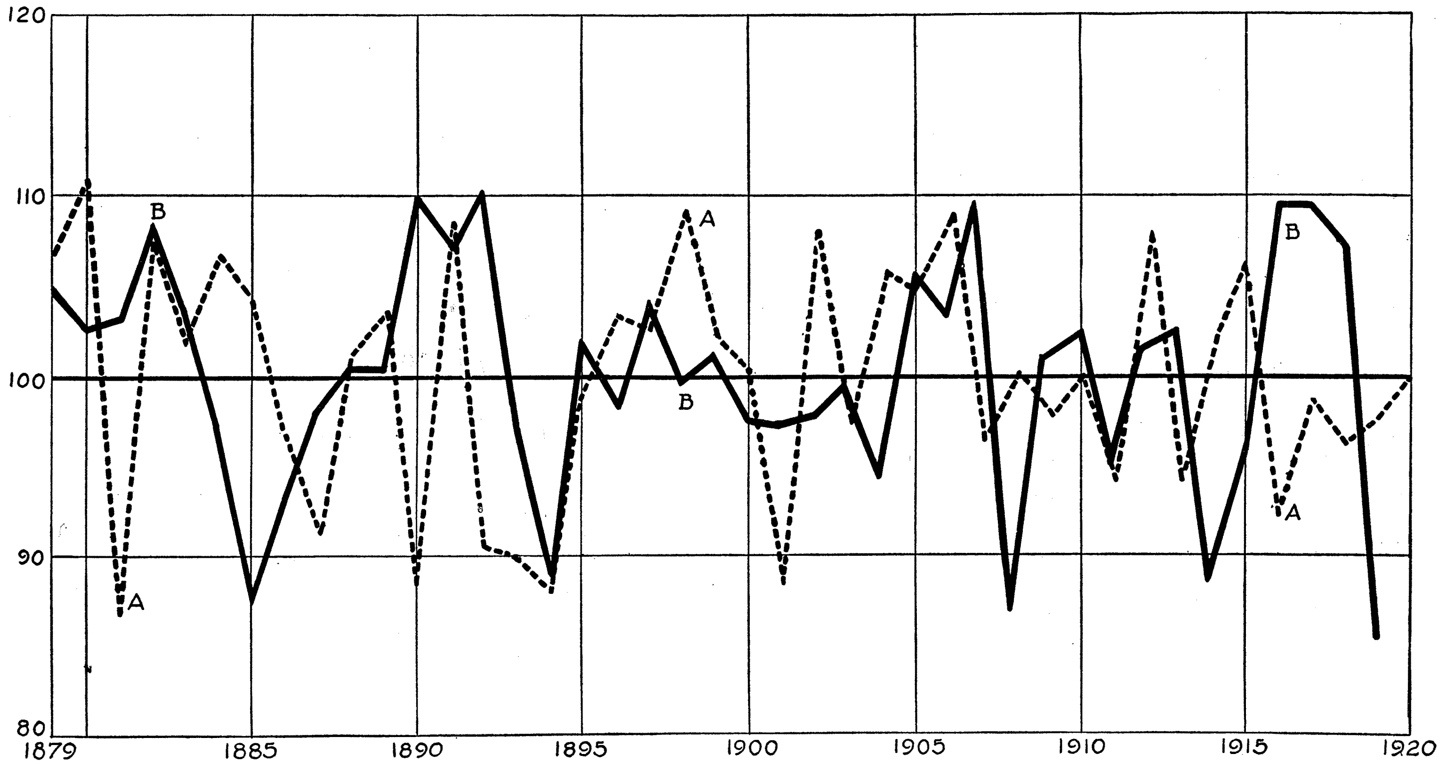

CHART XV. — ADJUSTED INDICES OF PHYSICAL PRODUCTION FOR (A) AGRICULTURE, 1879–1920, AND (B) MINING, 1879–1919.
(*Ordinates of secular trend = 100*)

TABLE XVII. — PERCENTAGES OF ACTUAL PRODUCTION TO ORDINATES OF SECULAR TREND OF TEN IMPORTANT MINERALS 1879–1919

Year	Gold	Silver	Pig iron	Zinc	Lead	Copper	Bituminous coal	Anthracite coal	Petroleum	Coke
1879	112.0	106.1	85.0	....	85.8	200.0	85.3	109.6	114.9	....
1880	104.2	96.0	107.0	....	87.3	125.8	85.6	97.8	134.2	94.0
1881	101.0	99.4	105.1	....	100.0	101.4	96.8	102.7	126.8	99.6
1882	95.2	102.4	107.6	108.2	110.2	97.3	111.4	107.0	126.0	102.1
1883	88.5	96.0	98.7	103.9	114.8	99.9	115.0	111.2	89.2	103.4
1884	91.5	96.4	81.7	97.0	107.0	104.9	113.8	102.2	84.9	83.2
1885	94.8	97.4	75.3	92.5	96.1	103.1	92.7	100.8	71.1	79.4
1886	104.6	92.6	99.3	88.2	94.1	86.1	88.5	98.0	85.0	97.7
1887	100.1	93.2	105.4	96.1	102.2	88.2	98.5	101.1	80.2	100.5
1888	100.7	98.2	100.7	98.5	102.7	99.1	106.5	107.2	73.6	104.9
1889	109.9	103.3	111.8	96.6	103.5	90.1	94.2	100.8	88.4	117.3
1890	101.1	108.4	128.6	97.5	92.8	94.9	103.8	99.0	109.2	123.8
1891	102.9	111.6	110.2	116.4	113.0	96.2	104.3	104.2	122.6	104.7
1892	103.0	117.4	116.3	118.4	105.8	108.4	107.0	104.0	108.8	115.0
1893	103.3	107.1	86.6	101.2	97.0	96.7	103.3	103.4	99.4	85.8
1894	97.0	85.5	77.6	91.7	91.6	97.5	91.3	96.3	96.8	79.3
1895	99.9	93.3	105.7	103.7	93.0	98.7	99.7	104.1	99.5	109.5
1896	100.8	95.2	92.7	89.8	102.3	112.6	97.3	94.8	109.9	92.3
1897	98.0	101.5	89.4	111.1	99.5	108.3	96.5	88.8	186.1	90.7
1898	100.0	101.4	98.2	111.8	95.4	104.0	96.5	87.5	122.0	96.8
1899	101.0	101.2	103.5	110.8	89.3	102.7	100.5	96.3	98.0	106.2
1900	100.8	105.6	96.0	95.4	109.2	100.9	100.2	89.1	89.5	100.8
1901	98.3	100.4	102.2	98.4	102.4	92.8	97.4	101.9	82.6	97.9
1902	98.3	99.9	106.6	100.2	100.4	94.4	103.4	60.9	91.6	105.1
1903	89.0	97.2	100.6	93.6	100.8	93.6	104.2	107.0	91.5	96.9
1904	95.4	103.2	86.5	101.9	101.7	102.3	95.7	102.3	95.5	84.6
1905	102.8	98.6	113.4	103.6	100.6	105.5	101.1	106.0	99.5	107.9
1906	108.1	98.5	118.0	95.0	105.3	103.0	103.8	95.0	85.2	83.1
1907	102.0	97.6	113.9	100.1	105.8	92.6	112.8	111.3	103.0	120.8
1908	105.1	90.0	66.9	80.5	90.2	95.5	89.9	106.0	102.6	73.1
1909	109.0	93.0	103.2	92.1	98.3	105.4	97.5	100.8	98.0	104.8
1910	103.5	96.4	104.3	95.7	100.6	99.7	101.9	103.0	104.8	105.8
1911	102.8	101.0	86.4	98.1	101.5	97.0	94.5	107.8	103.7	85.9
1912	97.3	105.9	104.1	111.6	98.5	105.4	100.2	98.7	98.8	101.8
1913	91.4	110.0	104.1	111.0	99.8	99.6	102.1	104.8	104.2	102.7
1914	95.5	118.4	75.5	108.3	120.6	90.2	86.5	102.0	105.6	73.5
1915	100.8	121.7	93.2	139.0	115.2	104.9	87.0	97.8	106.4	85.0
1916	91.2	119.9	118.6	164.1	121.8	140.5	95.2	94.5	108.6	107.3
1917	81.2	114.6	112.1	163.8	117.6	132.9	100.9	105.4	115.7	105.3
1918	65.8	107.5	109.6	132.9	112.5	130.0	102.1	103.0	117.5	103.5
1919	55.1	87.1	84.2	117.8	86.0	86.4	78.2	88.1	119.7	79.3

clear that 1885, 1894, 1908, 1914, and 1919 were years in which production fell far below normal as judged by pre-war tendencies. Upon the other hand, 1882, 1890–92, 1905, 1907, and 1916–18 were years of relatively high output. Apparently production was accelerated during the war much as it has been typically in those stages of the business cycle which immediately precede the crisis.

In the second place, the course of mineral production is much less erratic than that of agricultural. We do not characterize it as less erratic because marked fluctuations from year to year are lacking; in fact, the index for mining shows changes as sudden and extreme as any registered by the index for agriculture. But these changes in the case of mining may be fairly characterized as exceptional. They appear to be confined upon the whole to years in the critical stage of the business cycle; *e. g.*, 1892–94, 1907–08. Aside from such periods

TABLE XVIII. — ADJUSTED INDEX OF PHYSICAL PRODUCTION FOR MINING, 1879–1919

(*Ordinates of Secular Trend = 100*)

Year	Index	Year	Index
1879	104.9	1900	97.4
1880	102.8	1901	97.4
1881	103.4	1902	97.7
1882	108.3	1903	99.6
1883	103.8	1904	94.4
1884	97.2	1905	105.4
1885	87.5	1906	103.4
1886	93.2	1907	109.2
1887	97.8	1908	87.2
1888	100.4	1909	101.0
1889	100.4	1910	102.5
1890	109.9	1911	95.2
1891	107.2	1912	101.6
1892	110.0	1913	102.5
1893	97.0	1914	88.9
1894	89.0	1915	96.1
1895	101.9	1916	109.4
1896	98.4	1917	109.5
1897	103.9	1918	107.1
1898	99.8	1919	85.2
1899	101.2		

as these, mineral production has fluctuated within much narrower limits than has agricultural production. The fundamental differences between the two lines of production are clearly exposed in the adjusted indices.

INDICES FOR AGRICULTURE AND MINING COMBINED

Agriculture and mining together supply the greater part of the raw materials from which production and consumption goods are subsequently manufactured. A combination of the agricultural and mineral indices therefore yields a serviceable index of the volume of production of raw materials. Following the line of previous analysis both unadjusted and adjusted indices of raw-material production may be constructed. The unadjusted index may be obtained by combining in the form of a weighted geometric mean the unadjusted indices of agriculture and mining; and the adjusted index, by combining in the form of a weighted arithmetic mean the adjusted indices of agriculture and mining.

The only new problem lies in the weighting of total agricultural and total mineral production. The method adopted follows closely that employed in computing the separate indices of agriculture and mining. Instead of taking, however, an average of annual values for the five-year period, 1909–13, the aggregate values of agricultural and mining output for the single year 1909 are used. This change is made because the reports of the thirteenth decennial Census seem to constitute the best estimate of the relative aggregate value of agricultural and mineral production in this country during recent years. The Census figure for the total value of all crops in the United States in 1909 is $5,487,000,000.[1] The corresponding figure for all mineral products is $1,238,000,000.[2] The relative importance of the two, therefore, is in the proportion of 4.4 (agriculture) to 1 (mining). In combining the separate agricultural and mineral indices, these weights are employed.

The unadjusted raw-material index appears in Table XIX and Chart XVI. Naturally, as a consequence of the weights used, the index is much more nearly like the unadjusted index for agriculture than like that for mining. The volume of raw-material production in the five years just before the war was about two and one-half times that in 1879. During 1917–18 production rose about 16 per cent above the pre-war level. For agriculture and mining combined, production in 1881, 1890, 1892–94, 1901, 1907–09, 1911, 1913, and 1916 was relatively low; in 1882, 1891, 1898, 1902, 1906, 1912, 1915, relatively high.

TABLE XIX. — UNADJUSTED INDEX OF PHYSICAL PRODUCTION FOR AGRICULTURE AND MINING, 1879–1919

(*Average for 1909–13 = 100*)

Year	Index	Year	Index
1879	36.3	1900	74.4
1880	39.7	1901	68.5
1881	34.4	1902	84.4
1882	43.3	1903	80.6
1883	43.1	1904	87.6
1884	46.0	1905	91.3
1885	46.0	1906	96.5
1886	45.7	1907	90.4
1887	45.5	1908	91.3
1888	51.5	1909	94.4
1889	54.0	1910	98.9
1890	49.8	1911	94.1
1891	60.5	1912	109.8
1892	54.0	1913	100.3
1893	54.1	1914	106.5
1894	53.0	1915	112.8
1895	62.0	1916	105.3
1896	66.0	1917	112.9
1897	67.5	1918	111.9
1898	73.7	1919	110.6
1899	73.2		

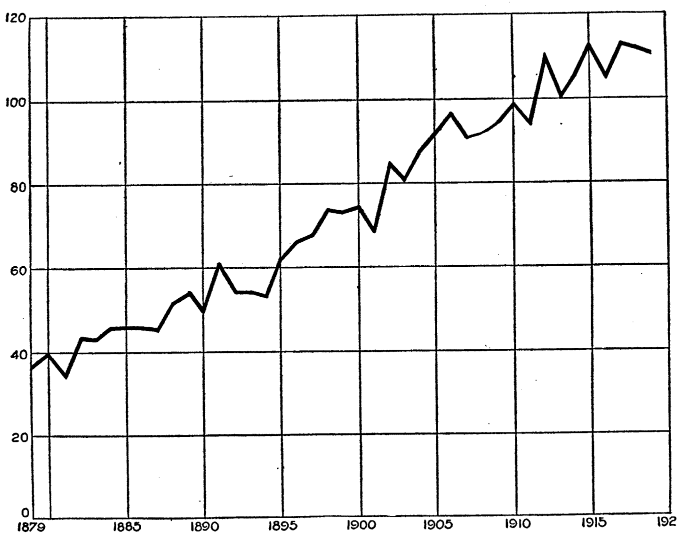

CHART XVI. — UNADJUSTED INDEX OF PHYSICAL PRODUCTION FOR AGRICULTURE AND MINING COMBINED, 1879–1919.

(*Average for 1909–13 = 100*)

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[1] Thirteenth Census of the United States, *Abstract*, pp. 361, 363.

[2] *Ibid.*, p. 544.

The adjusted raw material index is given in Table XX and Chart XVII. Again there is close resemblance to the corresponding index for agriculture. The six lowest points are in 1881, 1887, 1890, 1892–94, 1901, and 1911; the seven highest, in 1880, 1882, 1891, 1898, 1902, 1906, and 1912. For raw materials as a whole, 1919 was an unfavorable year, the index of production standing at 95.8. In general, fluctuations in the volume of production since 1906 are rather more erratic than before that year. Thus during the earlier period, conditions were consistently favorable in 1882–84, 1896–99, and 1904–06. No similar periods have occurred since 1906. The full explanation of such differences and the correlation of the volume of physical production with the general business cycle are tempting lines of investigation. Their pursuit, however, had best await further study of the course of physical production, and in particular, the extension of the study to the field of manufacture.

Table XX. — Adjusted Index of Physical Production for Agriculture and Mining, 1879–1919

(*Ordinates of Secular Trend* = 100)

Year	Index	Year	Index	Year	Index	Year	Index
1879	106.0	1890	92.9	1900	99.7	1910	100.5
1880	109.3	1891	108.2	1901	90.2	1911	94.2
1881	89.9	1892	94.1	1902	106.1	1912	107.0
1882	107.3	1893	91.3	1903	97.9	1913	95.7
1883	102.2	1894	88.1	1904	103.5	1914	100.1
1884	104.9	1895	99.6	1905	104.9	1915	104.4
1885	101.4	1896	102.5	1906	108.0	1916	95.5
1886	96.2	1897	102.9	1907	98.8	1917	100.6
1887	92.7	1898	107.3	1908	97.8	1918	98.1
1888	101.3	1899	102.0	1909	98.4	1919	95.8
1889	102.9						

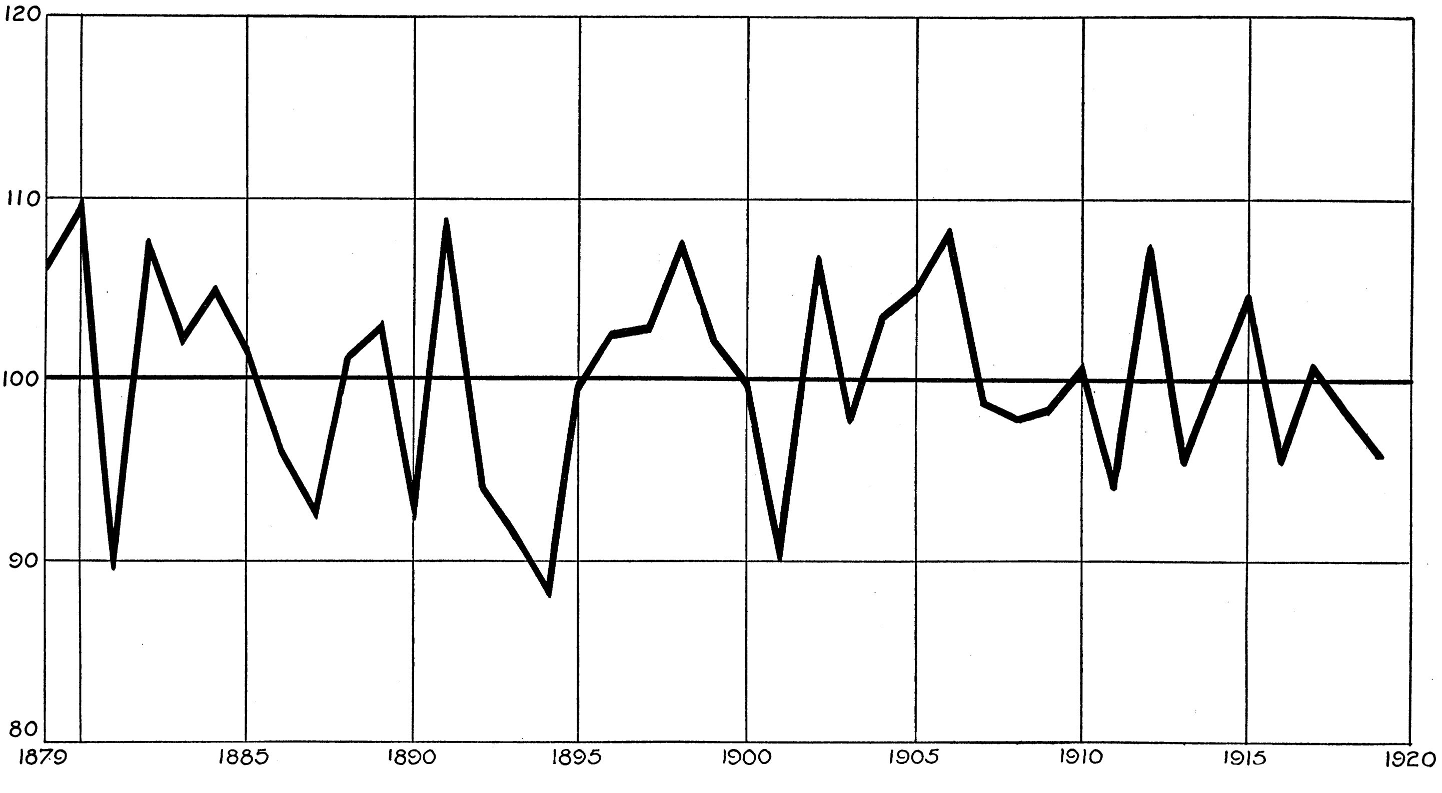

Chart XVII. — Adjusted Index of Physical Production for Agriculture and Mining Combined, 1879–1919.

(*Ordinates of secular trend* = 100)